U. S. FOREST SERVICE

RESEARCH NOTE NC-11

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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Seasonal Fluctuation in Moisture Content of Pine Foliage

Green or living fuels, particularly pine crowns, are commonly consumed by forest fires burning during hot, windy weather. In some cases the pine crowns burn rapidly; in young pine stands crown fire has been known to burn ahead of surface-burning fire for some distance before dropping to the ground.

We know that moisture content of dead or cured fuels greatly influences the way they burn. So we conducted a study to find out to what extent seasonal variations in moisture content of green pine foliage influence the crown-fire potential of coniferous stands in the Lake States.

Sampling Methods

Red pine needle samples were collected during 1962 and 1963 from three stands: two located about 10 miles north of St. Paul, Minn., and one in the Manistee National Forest in Michigan. Jack pine needle samples were collected during 1963 from the Manistee National Forest. Needles were collected on irregularly scheduled days between noon and 3:00 p.m.

Each sample, consisting of eight subsamples of 10 to 20 grams, was analyzed for moisture content by ovendrying. Old-growth (second-year or older) needles were separated from new-growth needles in the subsamples. New-growth needles collected at the Minnesota sites during April-June 1963 were from the 1962 growing season and were almost 1 year old. The sampling error was estimated to be 5 percent or less of the mean percent moisture content (dry basis) using the .95 confidence level.

Supplemental samples were collected to determine if meaningful differences in moisture content existed between needles taken from upper crown and lower crown positions.

Results

Seasonal trend of needle moisture-content was similar for both species, both locations, and both years (figs. 1, 2, and 3). The latter was true despite the fact that 1962 was a wet year in Minnesota (summer precipitation 4.5 inches above normal) and 1963 a dry year (5.2 inches below normal). Both years were dry in Michigan: precipitation was 5.3 inches below normal during the summer of 1962 and 6.5 inches below in 1963.

Moisture content of new-growth needles decreased steadily throughout the summer from about 200 percent in late June to about 135 percent in October. Both Buck (1939, 1965) and Philpot (1963), working with different species, reported similar decreases in moisture content of new-growth foliage with the advance of the growing season.

Moisture content of old-growth needles usually fluctuated between 100 and 125 percent. Only a few samples contained less than 100 percent moisture — the lowest being 95 percent in red pine in Minnesota during the drier, slightly cooler spring of 1963 (fig. 2). Needle moisture averaged about 4 percent less during the spring of 1963 than in 1962.

No difference in needle moisture content was found between samples of the upper and lower crowns of red pine.

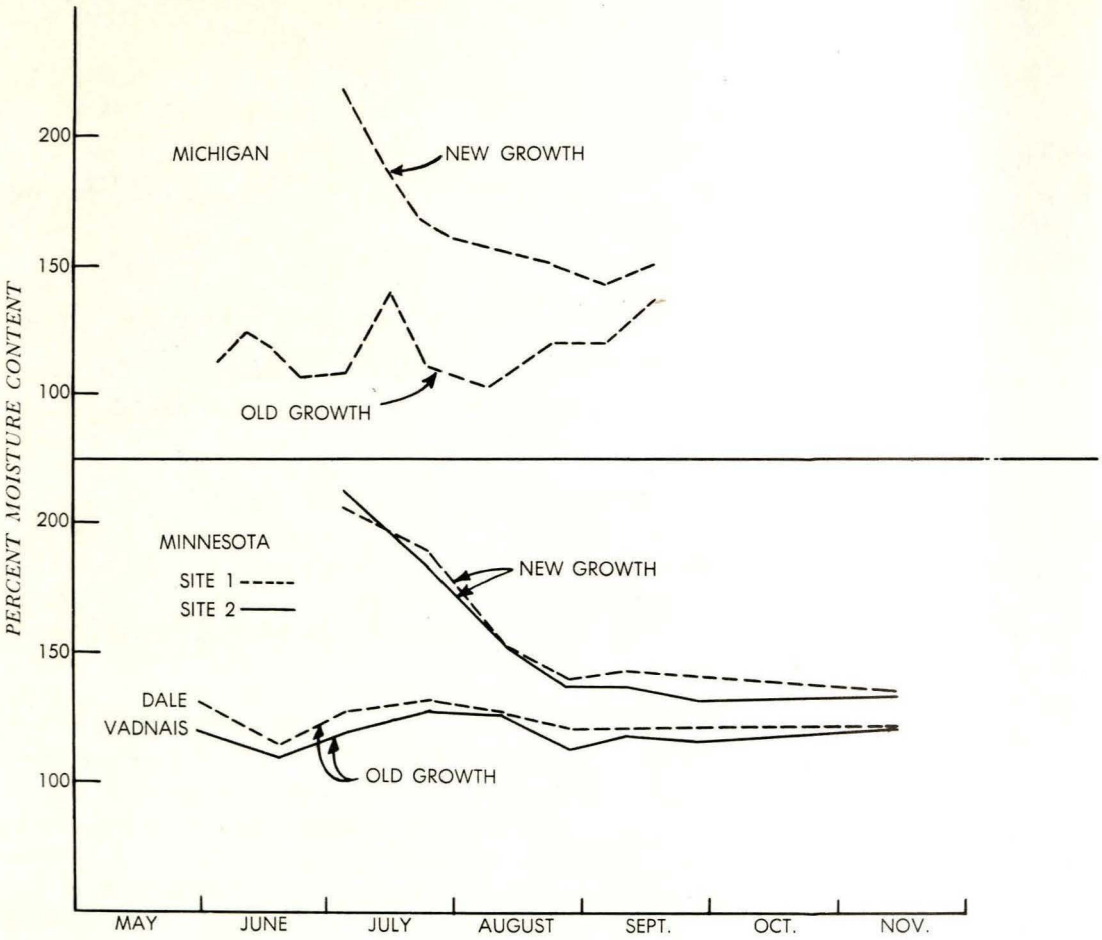

FIGURE 1. — Moisture content of red pine needles during 1962.

Discussion

Seasonal fluctuation of moisture in mature foliage is the result of a complex interaction of factors such as soil moisture tension and evaporation potential of the air. The cause of the fluctuation is not completely understood. However, it is evidently due in part to cell wall thickening as the needles mature, which results in an increase of dry weight in proportion to moisture. Richards (1940) found that similar trends in seasonal moisture content of freshly picked snowbrush leaves resulted in a net change of caloric content from 900 calories per gram in spring to 2,000 calories per gram in autumn.

Fuels containing 100 to 125 percent moisture do not logically constitute a serious fuel hazard. In fact, at moisture contents as low as 65 percent, Scots pine, balsam fir, and white spruce Christmas trees are relatively resistant to combustion. Van Wagner (1961) found that flaming ceases immediately on removal of an 8-inch Bunsen flame ignition source. We must conclude then that live needle moisture content is not a critical factor in crown fires.

We do know, however, that coniferous crowns will support combustion during severe burning situations. Under hot and windy conditions the convective and radiant heat produced from fires burning in dry ground fuels may ignite overstory green fuels. At other times, under apparently similar conditions, ignition of green fuels does not occur.

If needle moisture is not the critical factor, what is? Hubert suggested in 1932 that leaf oil content of coniferous needles might have an influence on forest fires. He showed that oils extracted from green pine and fir foliage have average flash points of 54° C. and 46° C. respectively. Extractable oils

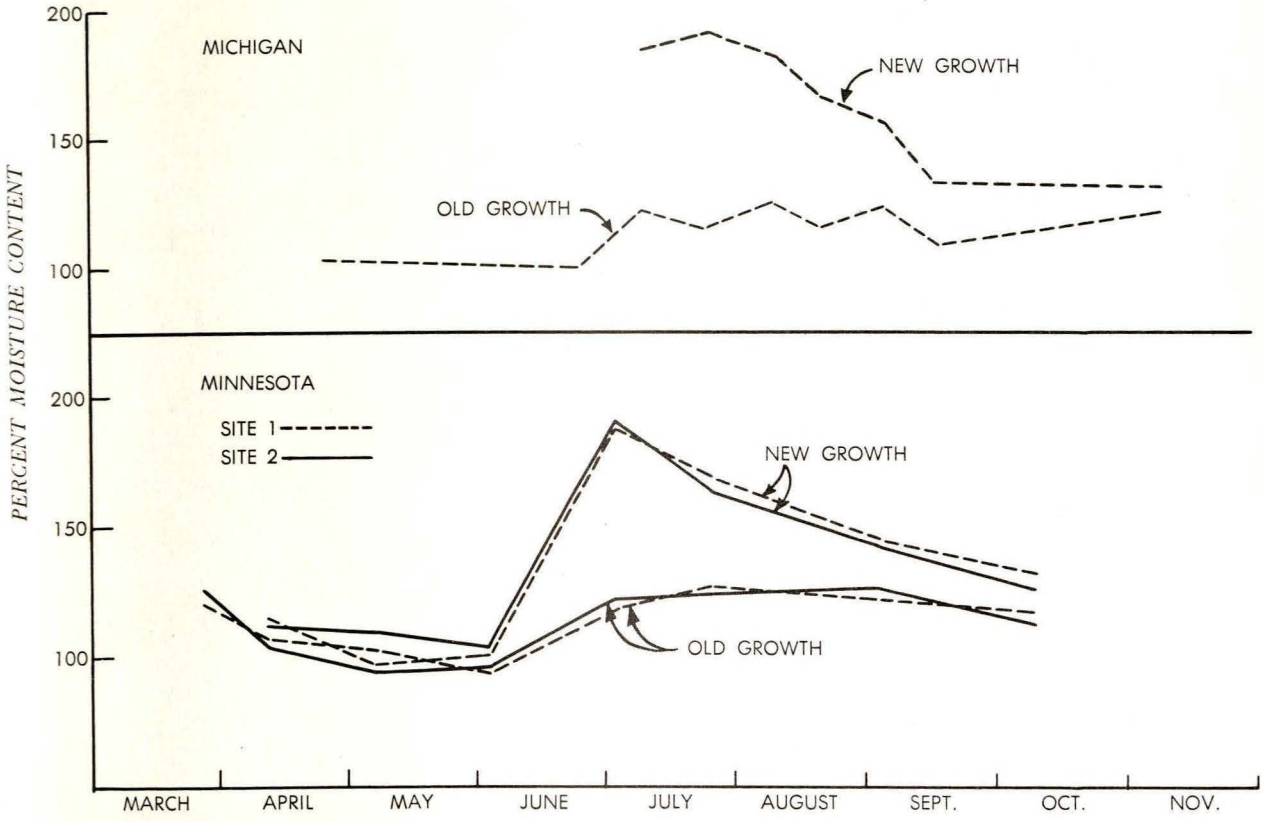

FIGURE 2. — Moisture content of red pine needles during 1963.

amounted to .015 to 1.2 percent of the total green weight. Exactly how variations of oil content affect the flammability of green needles is not known. Perhaps a higher concentration of nonaqueous volatiles (oils, fats, resins, and waxes) in green foliage during certain seasons or under particular weather conditions causes an acceleration in moisture release during preheating. This would provide a threshold for crown-fire development.

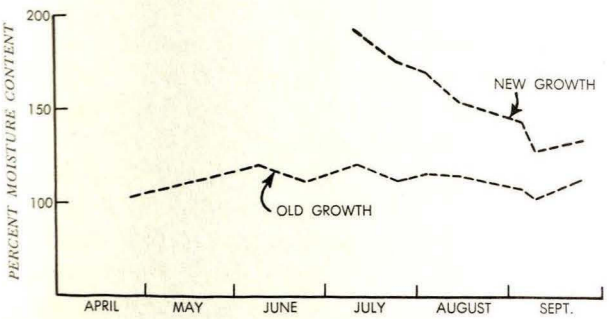

FIGURE 3. — Moisture content of jack pine needles in Michigan during 1963.

At any rate, in our search for a satisfactory explanation for crown fires we must apparently look beyond needle moisture content.

Literature Cited

Buck, C. C.
1939. Progress report on variations in the moisture content of green brush foliage on the Shasta Experimental Forest during 1938. U.S. Forest Serv., Calif. Forest & Range Exp. Sta. (unpublished manuscript).

Buck, C. C.
1965. Personal communication: Memorandum, Forest Fire Research, 11/16/65, 2 pp. (On file at North Central Forest Exp. Sta.)

Hubert, E. E.
1932. Brief study on conifer needle oils. J. Forest. 30: 340-341.

Philpot, C. W.
1963. The moisture content of ponderosa pine and white leaf Manzanita foliage in the Central Sierra Nevada. U.S. Forest Serv. Res. Note PSW-39, 7 pp. (Pacific Southwest Forest & Range Exp. Sta.)

Richards, Leon W.
1940. Effects of certain chemical attributes of vegetation on forest inflammability. J. Agr. Res. 60: 833-838.

Van Wagner, C. E.
1961. Moisture content and inflammability in spruce, fir, and Scots pine Christmas trees. Can. Dep. Forest., Forest Res. Br. Tech. Note 109, 16 pp.

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